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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of

Applicants	: Burch et al.
Serial No.	: 10/623,674
Filed	: July 21, 2003
Title	: **HIGH EFFICIENCY FUEL PROCESSOR VIA STEAM INTEGRATION FROM A WATER-COOLED STACK**
Docket	: GMC 0044 PA/40320.48
Examiner	: Melissa J. Austin
Art Unit	: 1745

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APPEAL BRIEF

The present Appeal Brief is submitted in support of the Notice of Appeal filed by Certificate of Mailing on May 9, 2005 and received by the U.S. Patent and Trademark Office on May 11, 2005.

I. REAL PARTY IN INTEREST

The real party in interest in this appeal is the assignee of the present application, General Motors Corporation.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences known to the Appellants, the Appellants' undersigned legal representative or the assignee which will directly effect or be directly effected by or having a bearing on the Board's decision in the present appeal.

III. STATUS OF THE CLAIMS

Claims 1-12, 15-18, 20-22, and 24-30 are pending in this application. Claims 1-12, 15-18, 20-22, and 24-30 stand rejected and are the subject of the present appeal. Claims 13, 14, 19, and 23 have been cancelled. A copy of the appealed claims is set forth in the Appendix.

IV. STATUS OF AMENDMENT FILED SUBSEQUENT TO REJECTION ON APPEAL

An amendment after the final rejection set forth in the Official Action dated February 9, 2005 was entered for purposes of the appeal. The amendment was filed April 6, 2005.

V. SUMMARY OF THE INVENTION

The present invention is generally directed to a fuel processor based fuel cell system (independent claims 1, 21, and 28).

According to independent claim 1, the fuel processor based fuel cell system comprises a primary reactor adapted to generate a gaseous reformate from feed inputs comprising steam, and a high temperature proton exchange membrane fuel cell (HT-PEMFC) stack in fluid communication with the primary reactor. The HT-PEMFC stack is adapted to receive the gaseous reformate for generating electrical power and to generate the steam needed for the

primary reactor. The fuel processor based fuel cell system further comprises a compressor adapted to provide compressed air to the HT-PEMFC stack, anode and cathode exhaust condensers adapted to receive heat energy from a respective exhaust of the HT-PEMFC and to heat air used by the compressor, and a stack excess steam condenser, wherein the air is also used to condense a portion of the steam provided to the excess steam condenser before being fed to the compressor.

Claims 2-12, 15-18, 20, 29, and 30 depend from claim 1. According to claim 2, the feed inputs further comprise air, hydrogen-containing fuel, and combinations thereof. Claim 3 recites a fuel processor based fuel cell system further comprising a water gas shift (WGS) reactor in fluid communication between the primary reactor and the HT-PEMFC stack, and a primary reactor heat exchanger in fluid communication between the primary reactor and the WGS reactor to heat at least the steam before being used in the primary reactor with heat energy from the gaseous reformate. Claim 4 recites a fuel processor based fuel cell system further comprising a catalytic combustor in fluid communication with a superheat heat exchanger to heat at least the steam before being used in the primary reactor with heat energy from the catalytic combustor. Claim 5 recites a fuel processor based fuel cell system further comprising a WGS reactor heat exchanger provided in fluid communication between a WGS reactor and the HT-PEMFC stack, wherein the WGS reactor heat exchanger is adapted to heat the steam before being used in the primary reactor with heat energy from the gaseous reformate.

According to claim 6, the primary reactor is selected from the group consisting of an auto-thermal reactor and a steam reformer. Claim 7 recites that a portion of about two-thirds to about one-half of vaporized water in the steam is recondensed in the stack excess steam condenser and recycled to the HT-PEMFC stack for cooling needs. According to claim 8, a

portion of about one-third to one-half of vaporized water in the steam is used in the primary reactor. Claim 9 recites a fuel processor based fuel cell system further comprising a catalytic combustor. Claim 9 further recites that excess hydrogen unconsumed by the HT-PEMFC stack in a catalyst reaction using the gaseous reformate is fed into the catalytic combustor to maintain a temperature required for producing the gaseous reformate in the primary reactor.

Claim 10 recites a fuel processor based fuel cell system further comprising a catalytic combustor in fluid communication with a combustor air preheat heat exchanger, which is adapted to receive heat energy from combustor exhaust and to preheat air used in the catalytic combustor. Claim 11 recites a fuel processor based fuel cell system further comprising anode and cathode exhaust liquid separators adapted to recover water from anode and cathode exhausts from the HT-PEMFC stack. Claim 12 recites a fuel processor based fuel cell system further comprising a stack coolant liquid separator to separate liquid water from the steam exiting the HT-PEMFC stack. Claim 15 recites a fuel processor based fuel cell system further comprising an anode exhaust preheat heat exchanger receiving anode exhaust from the HT-PEMFC stack and a bypass circuit used to divert the gaseous reformate into the anode exhaust preheat heat exchanger to provide greater heat input to the anode exhaust before sending the gaseous reformate to the HT-PEMFC stack.

According to claim 16, the HT-PEMFC stack has an anode stoichiometry from about 1.0 to about 1.3. Claim 17 recites that the primary reactor uses a ratio of steam to fuel carbon (S:C) from about 2 to about 5. Claim 18 recites that the primary reactor uses a ratio of atomic oxygen in air flow to carbon in fuel flow (O:C) from about 0.6 to about 1.5. Claim 20 recites a fuel processor based fuel cell system further comprising a water/steam separator to remove excess water contained in the gaseous reformate before being fed to the HT-PEMFC stack

Claim 29 recites a fuel processor based fuel cell system wherein the HT-PEMFC stack has an anode stoichiometry in a preferred range of about 1.1 to about 1.2. Claim 30 recites that the primary reactor uses a ratio of atomic oxygen in air flow to carbon in fuel flow (O:C) in a preferred range of about 0.75 to about 0.8.

Independent claim 21 recites a fuel processor based fuel cell system comprising a reactant stream comprising steam, a primary reactor adapted to generate a gaseous reformate using the reactant stream, and a primary reactor heat exchanger in fluid communication with the primary reactor to preheat the reactant stream. Claim 21 also recites a high temperature proton exchange membrane fuel cell (HT-PEMFC) stack adapted to receive the gaseous reformate for generating electrical power, wherein the HT-PEMFC stack is cooled by water and the steam is provided via water vaporization of the water in the HT-PEMFC stack. Claim 21 further recites a catalytic combustor, and a superheat heat exchanger adapted to receive heat energy from the catalytic combustor to superheat the reactant stream, wherein the superheated reactant stream is then combined with compressed air before being used in the primary reactor.

Claims 22 and 24-27 depend from claim 21. Claim 22 recites that the reactant stream further comprises a hydrogen-containing fuel, air, and combinations thereof. Claim 24 recites a fuel processor based fuel cell system wherein the superheated reactant stream combined with compressed air is further combined with a hydrogen-containing fuel before being used in the primary reactor. Claim 25 recites a fuel processor based fuel cell system further comprising a water gas shift (WGS) reactor provided in fluid communication with the primary reactor, a WGS heat exchanger in fluid communication with the WGS reactor, and an optional final CO-polishing stage provided in fluid communication between the WGS heat exchanger and the HT-PEMFC stack. Claim 27 recites a fuel processor based fuel cell system further comprising a

water injector used to put water into the reactant stream prior to entering into the superheat heat exchanger in order to provide the required steam for the primary reactor at startup.

Independent claim 28 recites a fuel processor based fuel cell system comprising a reactant stream comprising steam, a primary reactor adapted to generate a gaseous reformate using the feed inputs, and a high temperature proton exchange membrane fuel cell (HT-PEMFC) stack adapted to receive the gaseous reformate for generating electrical power. The HT-PEMFC stack is cooled by water and the steam is provided via water vaporization of the water in the HT-PEMFC stack. Claim 28 further recites a water gas shift (WGS) reactor in fluid communication between the primary reactor and the HT-PEMFC stack, a primary reactor heat exchanger situated between the primary reactor and the WGS reactor to preheat the reactant stream, a catalytic combustor, and a superheat heat exchanger adapted to receive heat energy from the catalytic combustor to superheat the reactant stream. The superheated reactant stream is then combined with compressed air before being used in the primary reactor.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The issues on appeal are the rejections of claims 1-12, 15-18, 20-22, and 24-30 under 35 U.S.C. §103(a). Claims 1-12, 15-18, 20, 29, 30 are rejected primarily based on the combination of Grasso (U.S. 2001/0004500) and Bloomfield (U.S. 3,982,962). Claim 1-3, and 6-9 are rejected based on those references further in view of Mugerwa (*Fuel Cell Systems*). Claim 4 is rejected further in view of Beshty (U.S. 4,670,359). Claim 5 is further in view of Towler (U.S. 6,375, 924). Claim 10 is rejected further in view of Clawson (U.S. 2002/00004152 A1) and Baukal Jr (*Heat Transfer in Industrial Combustion*). Claims 11 and 20 are rejected further in view of Buswell (U.S. 5,360,679). Claim 12 is rejected further in view of Okada (U.S. 5,302,470). Claim

15 is rejected further in view of Van Dine (U.S. 6,331,366). Claims 16 and 29 are rejected further in view Hallum (U.S. 2002/0081466) and Cownden (U.S. 2002/0015870). Claim 17 is rejected further in view of Cutright (U.S. 2002/0160239) and Okada. Claims 18 and 30 are rejected further in view of Kunitake (U.S. 2002/0046889). Claim 21, 22, and 24 were rejected in view of Eggert (*Characteristics of an Indirect-Methanol Fuel Cell System*) and Okamoto (U.S. 2002/177016 A1), and claims 25-28 were rejected based on the combination of Eggert and Okamoto further in view of Towler (claim 25), Grasso and Baukal (claim 26), Van Dine (U.S. 2003/0027025 A1) (claim 27), or Bloomfield and Mugerwa (claim 28).

VII. <u>ARGUMENTS</u>

Appellants submit that the fuel processor based fuel cell system defined by independent claims 1, 21, 28, and all claims dependent thereon, are nonobvious over and patentably distinguishable from the references cited by the Examiner. Accordingly, the rejection under 35 U.S.C. §103(a) should be reversed, and favorable action by the Board is respectfully requested.

A. <u>The Examiner's Position</u>

Referring to independent claim 1 and dependent claims 2, 3, and 6-9, the examiner asserts that these claims are obvious in light of the combination of Grasso and Bloomfield, further evidenced by Mugerwa.

Grasso is cited for teaching a reformer able to produce a reformate from a reactant stream comprising fuel, air, and steam. Grasso is also cited for teaching a water gas shift (WGS) reactor, and a PEM fuel cell stack. Because Grasso is cited for teaching a PEM fuel cell stack, the examiner asserts that Grasso also teaches a high temperature proton exchange membrane fuel cell (HT-PEMFC), wherein steam can be generated by the fuel cell via vaporization of cooling

water and then fed to the reformer. Grasso is also cited for teaching a catalytic burner that oxidizes excess reformed fuel from the anode exhaust, wherein the burner exhaust may be delivered to a steam generator operable to produce steam from a fuel cell cooling stream. As the examiner concedes, Grasso fails to teach a compressor to provide air to the fuel cell stack, anode, cathode, and stack excess steam condensers, a heat exchanger between the primary reactor and WGS reactor, or the use of a catalytic combustor to maintain the temperature in the primary reactor.

To cure these noted deficiencies, the examiner combines the teachings of Grasso with the teachings of Bloomfield, by stating one skilled in the art would know to combine the teachings of Grasso and Bloomfield to reduce utility costs. Bloomfield is cited for teaching a fuel cell power plant with a thermal management portion operable to cool the fuel cell, wherein the cooling water is at least partially vaporized to steam. Bloomfield is also cited for teaching a heat exchanger between the primary reactor and the WGS reactor, a catalytic burner in a heat exchange relationship with the reformer, anode, cathode, and stack excess condensers, and a compressor. The examiner cites Bloomfield as teaching that the water/steam produced in the fuel cell undergoes several heat exchange relationships to vaporize and superheat the steam before being delivered to a valve, wherein a portion of the steam is delivered to the reactor and the remaining portion is recycled back to a cooling loop through a turbine and condenser. As the examiner concedes, Bloomfield is silent as to the fractions sent to the reformer and to the cooling loop, but asserts broadly that one skilled in the art would be familiar with the fractions. Bloomfield fails to teach that the air heated by the condensers may be fed to the compressor.

To cure this deficiency, the examiner consults Mugerwa, which generally states "the greater degree of interaction possible between the fuel cell and fuel processing subsystems the

better the combined performance and system design will be." Based on these general teachings in Mugerwa, the examiner modifies Bloomfield to teach that air heated by the condensers may be fed to the compressor.

The examiner rejects the remaining claims dependent on claim 1 by combining the above teachings of Grasso and Bloomfield with the following references to cure the deficiencies of Grasso and Bloomfield. Referring to claim 4, the examiner cited Grasso, and Bloomfield, further in view of Beshty (4,670,359), wherein Beshty is cited for teaching a combustor that provides heat to a superheat heat exchanger, which is used to heat the steam before being fed to the primary reactor. The examiner rejects claim 5 based on Grasso, and Bloomfield, further in view of Towler (6,375,924), wherein Towler is cited for teaching a WGS reactor heat exchanger, which receives a gaseous reformate from a shift reaction zone (WGS reactor) so that the WGS heat exchanger heats and partially vaporizes a deionized water stream. Towler does not teach that the WGS heat exchanger may heat a stream comprising steam wherein the water was generated from cooling water provided to the fuel cell stack, so the examiner bridges the teaching gap through creative claim interpretation. The examiner states "adapted to", as used in claim 5, means "capable of". Consequently, the examiner states that while the Towler WGS heat exchanger does not teach the heating of steam generated via vaporization of cooling water, the WGS heat exchanger is "capable of" heating the steam.

Claim 10 is rejected based on the combination of Grasso and Bloomfield further in view of Clawson (2002/0004152 A1) and Baukal (*Heat Transfer in Industrial Combustion*). Clawson is cited for teaching a combustor heat exchanger that preheats air using energy from the combustor exhaust before the air is fed to the combustor. Claim 11 and 20 were rejected based on Grasso, Bloomfield, and Buswell (5,360,679), wherein Buswell is cited for teaching a water

separator used in recovering water from the fuel cell, and a water/steam separator which removes water from the gaseous reformate stream. In rejecting claim 12, the examiner cites the combination of Grasso, Bloomfield, and Okada (5,302,470), wherein Okada is cited for teaching a gas/water separator used to separate liquid water from a coolant stream from the fuel cell stack.

Claim 15 is rejected based on Grasso, Bloomfield and Van Dine (6,331,366) wherein Van Dine is cited for teaching an anode exhaust preheat heat exchanger, which utilizes gaseous reformate to heat the anode exhaust prior to delivering the exhaust to the fuel cell. All cited references are silent as to a bypass circuit used to divert the gaseous reformate into the anode exhaust preheat heat exchanger.

Claim 16 and 29 are both rejected based on Grasso, and Bloomfield, further in view of Hallum (2002/0015870) and Cownden (2002/0015870), wherein Hallum is cited for teaching an anode stoichiometry of 1.0 and higher depending on the non-ideality of the stack. Cowden is cited for teaching an anode stoichiometry of 1.1 to 1.5. Claim 17 is rejected based on the teachings of Grasso, and Bloomfield further in view of Cutright (2002/0160239) and Okada, wherein the examiner asserts Okada teaches a molar ratio of S:C of between 2 to 5. Claims 18 and 30 are rejected on Grasso, Bloomfield, and Kunitake (2001/0004500), wherein Kunitake is cited for teaching the O:C ratios recited in claim 18 and 30.

Referring to independent claim 21, and dependent claims 22 and 24, the examiner asserts these claims are obvious under § 103 based on Eggert (*Characteristics of an Indirect-Methanol Fuel Cell System*), in view of Okamoto (2002/0046889). Eggert is cited for teaching a reformer that generates a gaseous reformate from a reactant stream comprising steam. Eggert is also cited for teaching a PEM fuel cell, which uses a reformate to produce electrical power, and contains a thermal management portion, wherein the water used to cool the fuel cell stack may also be used

for steam reformation in the primary reactor. Eggert is also cited for teaching an evaporator between the WGS reaction and reformer, a catalytic burner, which burns anode exhaust, fuel, and air to supply heat energy to the reformer and superheaters by superheating the fuel and steam before they are mixed and reacted in the reformer. Because Eggert is cited for teaching PEM fuel cells, the examiner broadly extends the teachings of Eggert to encompass high temperature PEM fuel cells. Eggert fails to teach the combining of the superheated reactant stream with compressed air before entering the reformer.

To cure this noted deficiency of Eggert, the examiner combines the teachings of Eggert with the teachings of Okamato. Okamoto is cited for teaching the supplying of air to a reformer from a compressor. The Okamoto system does not teach a superheater and also fails to teach the mixing of the superheated stream and compressed air stream before entering the reformer, however the examiner asserts that one skilled in the art would know to combine the superheated reactant stream of Eggert with the compressed air of Okamoto to promote water vapor reformate and partial oxidation reactions. Without citing any sources, the examiner further contends that the streams must be mixed prior to entering the reformer.

The examiner rejects the remaining claims on claim 21 by combining the above teachings of Eggert and Okamoto with the following references to cure the deficiencies of Eggert and Okamoto. Referring to claim 25, the examiner cites the combination of Eggert, Okamoto, and Towler, wherein Towler is cited for teaching a WGS heat exchanger in fluid communication with a WGS reactor. Claim 26 is rejected based on Eggert and Okamoto further in view of Grasso as evidenced by Baukal, wherein Grasso is cited for teaching an anode exhaust preheat heat exchanger. Claim 27 is rejected based on Eggert and Okamoto further in view of Van Dine (US 2003/0027025), wherein Van Dine is cited for teaching a water injector used to put water

into the reactant stream prior to entering a heat exchanger in order to provide the required steam for the primary reactor. Van Dine is silent as to superheat heat exchangers.

Similar to claim 21, claim 28 is rejected under § 103 based primarily on the above teachings of Eggert and Okamoto, but further in view of the teachings of Bloomfield and Mugerwa. Also similar to above, none of the references, singularly or in combination, teach or suggest, the mixing of superheated steam with compressed air prior to entering the reformer; however the examiner states this modification would be obvious one skilled in art, because it promotes water vapor reformate and partial oxidation reactions.

B. <u>Rejection of claims 1-3, and 6-9 based on Grasso, Bloomfield further in view of Mugerwa should be removed</u>

1. <u>The teachings of Grasso and Bloomfield further in view of Mugerwa do not establish a prima facie of obviousness for claim 1</u>

Independent claim 1 and its dependent claims are nonobvious in light of the teachings of Grasso, Bloomfield and Mugerwa, because these references, singularly or in combination, do not teach all of the claimed limitations recited in claim 1. Under MPEP 2143, three basic criteria must be met to establish prima facie obviousness. MPEP 2143. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. *Id.* Second, there must be a reasonable expectation of success. *Id.* Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. *Id.*

The teachings of Bloomfield and Grasso do not establish a prima facie case of obviousness, because these references fail to teach all elements of claim 1. Grasso and Bloomfield both fail to teach a HT-PEMFC fuel cell stack, i.e. a stack that operates at high

temperatures. The present specification defines high temperatures as between about 100 °C to about 150 °C. ¶ [0016]. Grasso teaches a conventional steam reforming method. ¶ [0033] Similarly, Bloomfield also teaches a fuel cell system with a conventional type of fuel cell. (Col. 3, lines 10-13). As stated in the present application, current conventional PEM fuel cells operate at about 60 °C to 90 °C. ¶ [0004]. As a result, the examiner errs by asserting that a teaching of a conventional PEM cell also teaches a HT-PEMFC, because neither of the cited references, singularly or in combination, teach nor suggest a PEM fuel cell operating at temperatures from about 100 °C to about 150 °C.

Furthermore, Grasso and Bloomfield fail to teach that air heated by the condensers may be used to condense a portion of the steam in the stack excess steam condenser. Moreover, the cited references also fail to teach that the anode and cathode exhaust condensers may heat the air used by the compressor, and fail to teach that the air used in the anode, cathode, and stack excess steam condensers may be fed to the compressor as recited in claim 1. Because the cited references do not teach or suggest these recited claim limitations, a prima facie case of obviousness cannot be established.

The examiner concedes that Bloomfield and Grasso fail to teach that air may be fed from the condensers to the compressor, but asserts that "one of ordinary skill in the art of plant design and optimization would recognize the potential to recycle the air from the condensers to compressor inlet" based on Mugerwa. Mugerwa states "the greater the degree of interaction possible between the fuel cell and fuel processing subsystems the better the combined performance and system design will be". pg 202.

However, Mugerwa's general statement provides no teaching or suggestion that would lead one of ordinary skill in the art to modify the teachings of Grasso and Bloomfield by

recycling the air from the condensers into the compressor. By asserting Mugerwa teaches this claim element, the examiner is applying an improper "obvious to try" argument in support of the obviousness rejection. See MPEP 2145(X)(B) "One cannot base obviousness upon what a person skilled in the art might try or might find obvious but rather must consider what the prior art would have led a person skilled in the art to do." *In re Tomlinson*, 150 USPQ 623 (CCPA 1966). An improper 'obvious to try' rationale is being applied when one skilled in the art would have "to vary all parameters or try each of numerous possible choices until one possibly arrived at a successful result, where the prior art gave either no indication of which parameters were critical or no direction as to which of many possible choices is likely to be successful". See MPEP 2145(X)(B)

In our case, Mugerwa's general assertion provides no guidance on what parameters will improve the design and performance of the plant. Mugerwa does not teach or suggest that recycling condenser air to the compressor inlet will provide the successful result of improved fuel cell plant design and performance. Thus, one of ordinary skill in the art must experiment with numerous plant parameters, without any suggestion or teaching in the references of what plant parameter modifications are likely to be successful in producing improved design and performance. Consequently, the examiner is applying an improper obvious to try rationale in support of the obviousness rejection. As a result, this recited claim element is not taught.

Furthermore, even if one skilled in the art by happenstance recycled the condenser air into the Bloomfield compressor, the examiner's hindsight modification would still not teach all of the elements of the claimed invention. As stated above, the combined teachings of Grasso, Bloomfield, and Mugerwa still fail to teach all claim elements, such as a HT-PEMFC stack. As a result, none of the cited references, singularly or in combination, teach or suggest all claim

elements recited in claim 1, thus a prima facie case of obviousness has not been established. Accordingly, claim 1 and all of its dependent claims are in condition for allowance.

C. <u>Claims 4, 10-12, 16-18, 20, 29, and 30, which depend from claim 1, are in condition for allowance.</u>

As demonstrated above, claim 1 is in condition for allowance. As a result, the above claims, which depend from claim 1, should also be in condition for allowance. Applicants respectfully traverse the rejections under § 103 for claims 4, 10-12, 16-18, 20, 29, and 30.

D. <u>Claim 5, which is rejected based on Grasso, Bloomfield, and Beshty, is independently patentable.</u>

The rejection of claim 5 is improper, because none of the cited references, singularly or in combination, teach or suggest all elements of the claimed invention. Towler is cited for teaching shift effluent coolers capable of heating a deionized water stream, but fails to teach a WGS reactor heat exchanger provided in fluid communication between a WGS reactor and an HT-PEMFC stack, wherein the WGS reactor heat exchanger is adapted to heat the steam before being used in the primary reactor with heat energy from the gaseous reformate.

To cure this deficiency, the examiner utilizes a "capable of" test, which the examiner created by interpreting the claim language "adapted to" to mean "capable of". The examiner uses the applicant's disclosure as a roadmap and asserts that the WGS heat exchanger is capable of heating the reactant stream comprising steam, which is created via vaporization of the cooling water. However, the examiner should consider what the prior art teaches, and what the prior art would lead one of skill in the art to do, not what components or teachings of the prior art are "capable of". As stated above, no reference teaches the heating of steam exiting the fuel cell as recited in the claims. Moreover, there is no teaching or suggestion that would lead one to modify

the Towler reference to teach this claimed element. By relying on the general teaching of minimizing utility costs, the examiner modifies the Towler teachings to teach a WGS heat exchanger, which heats a steam stream from the fuel cell stack, before being fed to the reactor. However, the goal of minimizing utility costs is a general principle inherent to most plant; therefore, it provides no guidance to one skilled in art. As a result, one or ordinary skill would have to experiment blindly with numerous plant parameters to achieve the claimed invention. Accordingly, none of the cited references, singularly or in combination, teach or suggest all elements of the claimed invention, and the examiner's use of hindsight reconstruction, improper examination tests, and obvious to try rationales do not bridge the teaching gap.

E. <u>Claims 7 and 8, which are rejected based on Grasso, Bloomfield, and Mugerwa, are independently patentable.</u>

Regarding claim 7 and 8, as the examiner further concedes, no reference teaches the fraction of steam recondensed in the stack excess steam condenser and recycled to the HT-PEMFC for cooling needs as recited in claim 7, or the fraction of steam to be used in the primary reactor as recited in claim 8. The examiner states one skilled in the art would be familiar with the amount of steam needed for the reforming reaction and for adequate cooling of the stack; however, the present specification is the only reference that applicant is aware of that teaches and quantifies these claimed fractional amounts. As a result, the examiner is utilizing an impermissible hindsight reconstruction of the prior art to teach the claimed invention. Grasso and Bloomfield generally teach thermal management in a fuel cell system, yet neither reference quantified what fractions should be recycled and/or fed to the reformer. Without any guidance one skilled in the art would be forced to blindly experiment with numerous steam fractions to find the proper range. Again, the examiner has invoked an obvious to try rational in support of

the obviousness rejection, which is impermissible. As a result, applicant asserts claims 7 and 8 are in condition for allowance, and the §103 rejection should be removed.

F. <u>Claim 15, which is rejected based on Grasso, Bloomfield, and Van Dine, is independently patentable.</u>

Claim 15 is independently patentable, because no reference teaches a bypass circuit used to divert the gaseous reformate into the anode exhaust preheat heat exchanger. The bypass circuit inherently requires a device operable to divert the gaseous reformate into the anode exhaust preheat heat exchanger. In the present application, the bypass circuit utilizes a bypass valve 84, which may divert the gaseous reformate. None of the cited references teach a bypass circuit having a device to divert the gaseous reformate to the anode exhaust preheat heat exchanger. Thus, claim 15 is in condition for allowance.

G. <u>The rejections of claim 21, and its dependent claims 22 and 24 based on Eggert and Okamoto, and the rejection of claim 28 based on Eggert, Okamoto, Bloomfield and Grasso should be removed.</u>

1. <u>The cited references do not establish a prima facie of obviousness for claim 21 and claim 28.</u>

Independent claims 21 and its dependent claims and independent claim 28 are nonobvious primarily in light of the teachings of Eggert and Okamoto, because none of these references, singularly or in combination, teach all of the claimed limitations recited in claims 21 and 28.

Similar to the argument for claim 1, none of the cited references, teach or suggest, a HT-PEMFC stack, which has an operating temperature of between about 100 °C to about 150 °C. Eggert is cited for teaching a HT-PEMFC stack, but does not teach that the fuel cell may operate

at these high temperatures. In fact, the Eggert PEM fuel cell stack has an operating temperature of only 80 °C. pg. 1330. Okamoto does not teach PEM fuel cells or the operating temperatures of the fuel cell. As a result, none of the cited references, singularly or in combination, teach or suggest all elements of claims 21 and 28.

In addition, none of the cited references, teach or suggest, the mixing of the superheated reactant stream with compressed air prior to entering the reactor, as suggested by the examiner. The examiner concedes that Eggert fails to teach this claimed element; therefore, the examiner modifies the teachings of Eggert with the teachings of Okamoto to cure the deficiency. However, the Okamoto reference is also deficient.

First of all, the system of Okamoto does not comprise a superheat heat exchanger, and does not discuss superheating at all in the publication. To the applicant's knowledge, the applicant's disclosure is the only reference that teaches mixing of the superheated and the compressed air streams, and is the only reference that teaches that mixing compressed air with superheated steam will be successful. When combining references, both the teaching or suggestion and the reasonable expectation of success must be found in the prior art and not based on an applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991); *see also* MPEP 2142. Reasonable expectation of success centers on the question of what would the prior art lead one of ordinary skill in the art to do. *In re Tomlinson*, 150 USPQ 623. Because Okamoto fails to teach that the compressed air stream can be mixed with a superheated stream or any other type of heated stream of Okamoto, one skilled in the art would not be led to mix the compressed air stream of Okamoto with a superheated stream as recited in claims 21 and 28, because neither reference teaches or suggests this claimed element. Furthermore, no reference,

except for the applicant's disclosure, demonstrates that the mixing of the superheated and compressed air streams contains a reasonable expectation of success.

Second, the cited references also fail to teach the mixing of the compressed air stream and the superheated streams prior to entering the reformer. The applicant respectfully disagrees with the examiner's unsupported assertion that the superheated reactant stream must be mixed with compressed air prior to entering the reformer. The prior art does not teach that the prior mixing is required, and the examiner provides no support for this asserted requirement. Moreover, it appears plausible that the compressed air and superheated reactant stream could be mixed upon entering the reactor without prior mixing of the streams. Accordingly, none of the cited references teach the claimed limitations of mixing compressed air and superheated reactant streams prior to entering the reactor as recited in claims 21 and 28.

Even if the examiner's hindsight modification yields the claimed mixing of the superheated stream with the compressed air stream prior to entering the reformer, the cited references still fail to teach a HT-PEMFC. As a result, none of the cited references, either singularly or in combination, teach all recited elements of independent claims 21 and 28, thus prima facie obviousness has not been established. Accordingly, claims 21 and its dependent claims and claim 28 should be in condition for allowance.

H. Claims 25, and 26, which depend from claim 21, are in condition for allowance.

As demonstrated above, claim 21 is in condition for allowance. As a result, the above claims, which depend from claim 21, should also be in condition for allowance. Applicants respectfully traverse the rejections under § 103 for claims 25 and 26.

I. Claim 27, which is rejected based on Eggert, Okamoto, and Van Dine, are Independently Patentable

For claim 27, none of the references, singularly or in combination, teach all elements of the claimed invention. Van Dine is cited for teaching a water injector used to put water into the reactant stream before entering into a heat exchanger; however, Van Dine does not teach superheat heat exchangers. As a result, none of the references teach or suggest that water may be injected into a reactant stream prior to entering a superheat heat exchanger. Thus claim 27 is in condition for allowance.

VIII. CONCLUSIONS

Independent claims 1, 21, 28, and all claims dependent thereon, are nonobvious over and patentably distinguishable from the references cited by the Examiner. Accordingly, the rejection under 35 U.S.C. §103(a) should be reversed. Favorable action by the Board is respectfully requested.

Respectfully submitted,
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APPENDIX

1. A fuel processor based fuel cell system comprising:

a primary reactor adapted to generate a gaseous reformate from feed inputs comprising steam;

a high temperature proton exchange membrane fuel cell (HT-PEMFC) stack in fluid communication with the primary reactor, said HT-PEMFC stack is adapted to receive the gaseous reformate for generating electrical power and to generate the steam needed for the primary reactor;

a compressor adapted to provide compressed air to the HT-PEMFC stack;

an anode exhaust condenser and a cathode exhaust condenser adapted to receive heat energy from a respective exhaust from the HT-PEMFC and to heat air used by the compressor; and

a stack excess steam condenser, wherein the air is also used to condense a portion of the steam provided to the excess steam condenser before being fed to the compressor.

2. A fuel processor based fuel cell system according to claim 1 wherein the feed inputs further comprises air, a hydrogen-containing fuel, and combinations thereof.

3. A fuel processor based fuel cell system according to claim 1 further comprising a water gas shift (WGS) reactor in fluid communication between the primary reactor and the HT-PEMFC stack, and a primary reactor heat exchanger in fluid communication between the primary reactor

and the WGS reactor to heat at least the steam before being used in the primary reactor with heat energy from the gaseous reformate.

4. A fuel processor based fuel cell system according to claim 1 further comprising a catalytic combustor in fluid communication with a superheat heat exchanger to heat at least the steam before being used in the primary reactor with heat energy from the catalytic combustor.

5. A fuel processor based fuel cell system according to claim 1 further comprising a WGS reactor heat exchanger provided in fluid communication between a WGS reactor and the HT-PEMFC stack, the WGS reactor heat exchanger is adapted to heat the steam before being used in the primary reactor with heat energy from the gaseous reformate.

6. A fuel processor based fuel cell system according to claim 1 wherein the primary reactor is selected from the group consisting of an auto-thermal reactor and a steam reformer.

7. A fuel processor based fuel cell system according to claim 1 wherein a portion of about two-thirds to about one-half of vaporized water in the steam is recondensed in the stack excess steam condenser and recycled to the HT-PEMFC stack for cooling needs.

8. A fuel processor based fuel cell system according to claim 1 wherein a portion of about one-third to one-half of vaporized water in the steam is used in the primary reactor.

9. A fuel processor based fuel cell system according to claim 1 further comprising a catalytic combustor, and wherein excess hydrogen unconsumed by the HT-PEMFC stack in a catalyst reaction using the gaseous reformate is fed into the catalytic combustor to maintain a temperature required for producing the gaseous reformate in the primary reactor.

10. A fuel processor based fuel cell system according to claim 1 further comprising a catalytic combustor in fluid communication with a combustor air preheat heat exchanger which is adapted to receive heat energy from combustor exhaust and to preheat air used in the catalytic combustor.

11. A fuel processor based fuel cell system according to claim 1 further comprising anode and cathode exhaust liquid separators adapted to recover water from anode and cathode exhausts from the HT-PEMFC stack.

12. A fuel processor based fuel cell system according to claim 1 further comprising a stack coolant liquid separator to separate liquid water from the steam exiting the HT-PEMFC stack.

15. A fuel processor based fuel cell system according to claim 1 further comprising an anode exhaust preheat heat exchanger receiving anode exhaust from the HT-PEMFC stack and a bypass circuit used to divert the gaseous reformate into the anode exhaust preheat heat exchanger to provide greater heat input to the anode exhaust before sending the gaseous reformate to the HT-PEMFC stack.

16. A fuel processor based fuel cell system according to claim 1 wherein the HT-PEMFC stack has an anode stoichiometry from about 1.0 to about 1.3.

17. A fuel processor based fuel cell system according to claim 1 wherein the primary reactor uses a ratio of steam to fuel carbon (S:C) from about 2 to about 5.

18. A fuel processor based fuel cell system according to claim 1 wherein the primary reactor uses a ratio of atomic oxygen in air flow to carbon in fuel flow (O:C) from about 0.6 to about 1.5.

20. A fuel processor based fuel cell system according to claim 1 further comprising a water/steam separator to remove excess water contained in the gaseous reformate before being fed to the HT-PEMFC stack.

21. A fuel processor based fuel cell system comprising:

a reactant stream comprising steam;

a primary reactor adapted to generate a gaseous reformate using the reactant stream;

a primary reactor heat exchanger in fluid communication with the primary reactor to preheat the reactant stream;

a high temperature proton exchange membrane fuel cell (HT-PEMFC) stack adapted to receive the gaseous reformate for generating electrical power, the HT-PEMFC stack being cooled by water and the steam being provided via water vaporization of the water in the HT-PEMFC stack;

a catalytic combustor; and

a superheat heat exchanger adapted to receive heat energy from the catalytic combustor to superheat the reactant stream, the superheated reactant stream is then combined with compressed air before being used in the primary reactor.

22. A fuel processor based fuel cell system according to claim 21 wherein the reactant stream further comprises a hydrogen-containing fuel, air, and combinations thereof.

24. A fuel processor based fuel cell system according to claim 21 wherein the superheated reactant stream combined with compressed air is further combined with a hydrogen-containing fuel before being used in the primary reactor.

25. A fuel processor based fuel cell system according to claim 21 further comprising a water gas shift (WGS) reactor provided in fluid communication with the primary reactor, a WGS heat exchanger in fluid communication with the WGS reactor, and an optional final CO-polishing stage provided in fluid communication between the WGS heat exchanger and the HT-PEMFC stack.

26. A fuel processor based fuel cell system according to claim 21 wherein anode exhaust from the HT-PEMFC stack before entering into the combustor to be consumed is preheated by an anode exhaust preheat heat exchanger which is adapted to receive heat energy from combustor exhaust.

27. A fuel processor based fuel cell system according to claim 21 further comprising a water injector used to put water into the reactant stream prior to entering into the superheat heat exchanger in order to provide the required steam for the primary reactor at startup.

28. A fuel processor based fuel cell system comprising:

a reactant stream comprising steam;

a primary reactor adapted to generate a gaseous reformate using the feed inputs;

a high temperature proton exchange membrane fuel cell (HT-PEMFC) stack adapted to receive the gaseous reformate for generating electrical power, the HT-PEMFC stack being cooled by water and the steam being provided via water vaporization of the water in the HT-PEMFC stack;

a water gas shift (WGS) reactor in fluid communication between the primary reactor and the HT-PEMFC stack;

a primary reactor heat exchanger situated between the primary reactor and the WGS reactor to preheat the reactant stream;

a catalytic combustor; and

a superheat heat exchanger adapted to receive heat energy from the catalytic combustor to superheat the reactant stream, the superheated reactant stream is then combined with compressed air before being used in the primary reactor.

29. A fuel processor based fuel cell system according to claim 16 wherein the HT-PEMFC stack has an anode stoichiometry in a preferred range of about 1.1 to about 1.2.

30. A fuel processor based fuel cell system according to claim 18 wherein the primary reactor uses a ratio of atomic oxygen in air flow to carbon in fuel flow (O:C) in a preferred range of about 0.75 to about 0.8.